



United States
Department
of Agriculture

Animal and
Plant Health
Inspection
Service

**Veterinary
Services**

EPM

Equine Protozoal Myeloencephalitis in the U.S.



National Animal Health Monitoring System

May 2001

Study Collaborators

- USDA:Animal and Plant Health Inspection Service (APHIS):Veterinary Services (VS)
 - Centers for Epidemiology and Animal Health (CEAH)
 - Veterinary Medical Officers and Animal Health Technicians in Equine '98 study states
- USDA:National Agricultural Statistics Service (NASS)
- State Veterinary Medical Officers in Equine '98 study states
- Equine '98 study participating owners/operators

Analytic Contributors

- P.S. Morley and J.L. Traub-Dargatz. Colorado State University, Fort Collins, CO USA
- W.J.A. Saville. The Ohio State University, Columbus, OH USA
- B.A. Wagner, L.P. Garber, A.H. Hillberg-Seitzinger, USDA:APHIS:VS, Centers for Epidemiology and Animal Health, Fort Collins, CO USA

Suggested bibliographic citation for this report:

NAHMS. 2001. Equine Protozoal Myeloencephalitis (EPM) in the U.S. USDA:APHIS:VS, CEAH, National Animal Health Monitoring System. Fort Collins, CO. #N312.0501.

Questions or comments on Equine '98 study methodology or data analysis:	Mr. Bruce Wagner
Information on reprints or other NAHMS reports:	Mr. Michael Durham
(970) 490-8000	NAHMSweb@aphis.usda.gov

Table of Contents

Abstract	1
Introduction	2
Methodology	5
Section I: Population Estimates.	9
A. Familiarity with EPM	9
1. Region	9
2. Size of operation	10
3. Primary use of resident horses	10
B. General Characteristics of EPM on Operations.	11
1. Veterinary diagnosis of EPM.	11
2. Region	12
3. Size of operation	13
4. Primary use of resident horses	14
5. Average number of cases of EPM per operation.	15
C. EPM Cases Developed from 3/1/97 - 2/28/98	17
1. Season of onset.	17
2. Method of diagnosis	18
3. Clinical signs.	19
4. Treatment.	20
5. Outcome	21
D. Description of Last Cases of EPM	22
1. Season of onset.	22
2. Year of onset	22
3. Method of diagnosis	23
4. Treatment.	24
5. Outcome	25
6. Lost use	26
7. Cost of diagnostic testing, veterinary care, and medication	28

Section II: Discussion	30
A. Quality of information	30
B. Occurrence of EPM in the United States	30
References	34
Appendix I: Sample Profile	38
A. Responding Operations	38
Appendix II: U. S. Equine Populations	39

Abstract

Objective (as part of the NAHMS Equine '98 study): Describe the occurrence of equine protozoal myeloencephalitis (EPM) in the U.S. Characterize horses reported to have EPM with regard to clinical signs, methods of diagnosis and treatment, cost of treatment and lost use, and clinical outcome. Characterize operation-level risk factors associated with the likelihood of identifying EPM on equine operations in the United States.

Design: Population-based cross-sectional survey.

Sample Population: Stratified random sample of equine operations in 28 states with at least three resident horses on January 1, 1998, representing 51.6 percent of operations with horses and 83.9 percent of horses in those 28 states.

Procedure: Questionnaires were administered on-site to operators by Veterinary Medical Officers or Animal Health Technicians. Analyses of data were weighted to account for study design, sampling fraction, and non-response to obtain appropriate population-based variance estimates.

Results: Overall, 59.8 percent of owners/operators interviewed had never heard of equine protozoal myeloencephalitis or EPM, and only 9.5 percent considered themselves knowledgeable about this disease. EPM was reported to have occurred on 1.0 percent of operations in the year prior to the study and on 3.3 percent of operations at any point in the operation's history. The incidence of EPM was estimated in the year prior to the study to be 14 new cases per 10,000 horses per year. The majority of operations where EPM was reported had only identified a single case at any time during their history. While this study was based on owner/operator reports of disease, 95.0 percent of cases recognized during the year prior this study were diagnosed by a veterinarian. Onset of disease was reported most commonly to occur during the summer or fall. The most common signs reported in cases occurring during the previous year were ataxia, limb weakness, lameness, and muscle atrophy. The most common methods used to diagnosis EPM in these horses were recognition of clinical signs, serology, and CSF analysis. Among the last cases recognized on operations for which duration of illness was at least 3 months, 39.7 percent were reported to recover completely, 37.4 percent improved but did not completely recover, 14.4 percent were sold or given away because they had EPM, and 7.1 percent died or were euthanatized because of EPM. For those EPM cases that completely recovered, relapsed following improvement, and showed no improvement after at least 3 months duration, the average number of days of lost use was 244 days. For those EPM cases that died because of EPM, an estimated 9.2 years of use were lost. Excluding cases that were less than 3 months in duration, the geometric mean cost to operations for diagnostic testing, veterinary care, and medications provided for the last diagnosed case of EPM was \$790.

Implications: EPM was reported to occur rarely in this study population, despite the use of owner reports to measure disease occurrence. Veterinarians were almost always employed in the diagnosis of this disease for cases occurring in the previous year. Despite its rare occurrence, this disease is a very serious health problem in affected horses and only about 40 percent of affected horses were reported to have recovered completely.

Introduction

What is Equine Protozoal Myeloencephalitis?

Equine protozoal myeloencephalitis (EPM) is a serious and often fatal neurologic disease of equids.¹⁻⁶ Animals affected by EPM can demonstrate a variety of clinical abnormalities, and signs can vary tremendously in severity. Classically, horses with EPM develop a variety of asymmetric neurologic deficits including gait abnormalities, ataxia, weakness, and focal muscle wasting.⁴⁻⁶ However, symmetric neurologic abnormalities are also seen frequently. The disease may be focal or multifocal in nature and may be manifested less frequently as a head tilt, facial paralysis, seizures, or even apparent behavioral changes.⁴⁻⁶ Horses of all ages can be affected, but horses are usually at least 6 months old when first diagnosed with EPM.

Sarcocystis neurona is the parasite thought to be the principal causative agent of EPM.^{1,4,5} Recent work suggests that *Neospora caninum* and/or *Neospora hughesi* infections can also cause neurologic disease that is clinically indistinguishable from that caused by *S. neurona*.⁷⁻¹⁰ However, *S. neurona* infections are apparently a much more frequent cause of EPM. The life cycle of *S. neurona* is complex and is not fully understood.⁶ Horses are considered an aberrant host for these parasites. The definitive hosts of *S. neurona* are believed to be members of the opossum family (*Didelphis virginiana* in North America and other members of the Didelphidae family in Central and South America).¹¹ The natural range of opossum species corresponds well with areas where EPM is commonly identified. EPM has been recognized in horses on other continents, but to date only in horses that originated from North America, Central America, and South America. A recent experimental study showed that the domestic cat can serve as an intermediate host, but the natural intermediate hosts for *S. neurona* remain unknown.^{6,12}

Why is EPM important?

EPM is a growing problem for the horse industry in the U.S. This disease has been diagnosed with increasing frequency by veterinarians throughout the U.S. during the past decade since commercial tests to detect *S. neurona* infection became available. Treatment of EPM is quite expensive, and both mildly or severely affected horses often require treatment for extended periods.⁴⁻⁶ Despite aggressive treatment, horses with EPM can be affected so severely that they must be euthanized, or they can develop permanent problems which affect their ability to be used for athletic activities.

Gathering information about this disease was identified by the equine industry as one of the highest priorities for the NAHMS Equine '98 study.¹³ This disease syndrome was described initially about 35 years ago, and substantial effort has been made during the past decade to improve our understanding of EPM. However, many questions remain unanswered about the occurrence of EPM and its impact on the U.S. horse industry. To date there have been no nationwide estimates regarding the incidence of EPM in the U.S. In addition, there have not been objective frequency estimates regarding the methods of diagnosis, treatments employed, cost of treatment and lost use, or the outcome for horses diagnosed with EPM. Further information regarding the risk factors for developing EPM was also needed.

How is EPM Diagnosed?

Making a definitive diagnosis of EPM in the live horse is challenging.⁴⁻⁶ Currently, there are no **universally** accepted methods for making a definitive diagnosis. It is important to understand that EPM, the disease, is different from documented exposure to *S. neurona*, the organism that causes the disease. A presumptive diagnosis of EPM can be made in some horses if they show neurologic signs that would not likely be caused by other diseases, such as cervical vertebral malformation or herpesvirus myelitis. In many other horses, how-

ever, these clinical signs could be caused by one or more other diseases. Many veterinarians make a presumptive diagnosis of EPM if *S. neurona* or antibodies to the parasite can be detected in cerebrospinal fluid (CSF) collected from horses with neurologic abnormalities, assuming that the CSF was not contaminated by blood during collection or because the blood-brain barrier has been injured.⁴⁻⁶ Recent studies suggest that some normal horses can have antibodies to *S. neurona* in CSF.¹⁴⁻¹⁷ Horses might also be assumed to have EPM if they respond favorably to treatments that are believed to kill the parasites causing this disease. A definitive diagnosis of EPM can be established after horses die by examining tissues of the brain and spinal cord using special techniques.^{18,19} But even necropsy tests can miss an infected animal due to the small number of organism required to cause disease.

Some of the methods used to identify exposure definitively to *S. neurona* include detection of specific antibodies (using the immunoblot or direct agglutination assays),^{2,6,20-22} detection of DNA from the organisms (using polymerase chain reaction assay),^{6,11,23,24} or identification of organisms in tissues (using culture or immunodiagnostic techniques).^{1,6,18} The most common method used to identify horses specifically that have been infected is the immunoblot assay. This diagnostic test became available commercially in 1992 and since then has been used widely in the U.S. to detect antibodies to *S. neurona* in serum and in CSF. Identification of *S. neurona*-specific antibodies in serum indicates that the animal has been exposed previously to *S. neurona*. Results of seroprevalence studies indicate that in some regions (California, Colorado, Florida, Kentucky, Missouri, Michigan, Ohio, Oregon, and Pennsylvania), approximately 30-60 percent of horses tested were exposed previously to *S. neurona*.²⁵⁻³¹ Not all exposed horses develop the disease EPM, but hospital based studies suggest that exposure can be documented more frequently in groups of EPM horses compared to clinically normal horses.^{15,25,28,32,33}

How is EPM Treated?

Several treatments have been used in horses diagnosed with EPM, and others are being investigated currently. Responses of horses with EPM treated at a few referral veterinary hospitals have been reported, but results of objective efficacy studies have not been published to date. A major emphasis of treatment is the elimination of the parasites from neurologic tissues. The treatment that has been reported to be used most often is a combination of antibiotic/antiparasitic drugs (a sulphonamide and pyrimethamine).⁴⁻⁶ Another antimicrobial drug that has been used infrequently is oxytetracycline. New drugs that are being investigated to determine their efficacy for eliminating the causative agent include diclazuril, toltrazuil, and nitazoxanide.³⁴⁻⁴³ Anti-inflammatory drugs (e.g., phenylbutazone and flunixin meglumine) and nutritional feed additives (e.g., vitamins such as folic acid and vitamin E) have been used as adjunct supportive treatments in horses with EPM.⁴⁻⁶ Acupuncture has also been used in an effort to diagnose and treat horses with EPM.⁴⁴

Can EPM Be Prevented?

Many aspects of the life cycle of *S. neurona* or the pathogenesis of EPM remain unknown. For example, little is known about the incubation period between exposure and the manifestation of clinical disease, why some exposed horses develop disease while others do not, or even how the parasite infects the central nervous system. It is likely that some horses are more susceptible to disease, but very few studies have examined factors affecting susceptibility of different horses.^{15,32,33} It is also likely that environmental or management factors (stress, diet, etc.) affect the occurrence of disease.¹⁶ However, very few studies have examined these factors. Because the sporocysts of *S. neurona* are passed in the feces of the opossum, it is likely that infective oocysts are introduced into the feed and water supply of horses and intermediate hosts.^{4,6} It is not known how the parasite behaves within a horse's body after it is ingested except that it moves ultimately to the central nervous system in some horses.

While it is likely that management conditions affect the likelihood of exposure to the causative agents and occurrence of clinical EPM, at the present time there is limited information about measures that are effective in preventing exposure to *S. neurona* or the occurrence of clinical disease. Some authorities have proposed that preventing access of opossums to hay, grain, pasture, and water sources may decrease the risk of exposure and disease.^{5,45} However, it is not clear that eliminating direct exposure of horses to wild opossums will eliminate completely the risk of disease because horses may be exposed to the parasite through other sources such as contaminated feed.¹⁶

USDA:APHIS:VS

put, and in addition, web site and 1-800 telephone call-in surveys were conducted from January 1 through March 15, 1997.

This collective feedback formed the basis for development of the Equine '98 study objectives shown on the inside back cover of this report.

Baseline health and management questionnaire phases

A goal for all NAHMS national studies is to include states that account for at least 70 percent of the animal and producer/owner populations in the U.S. The most recent data available on which to base the selection of states to be included in Equine '98 Study was the 1992 Census of Agriculture data for horses and ponies.

States which met a minimum contribution to the U.S. total for number of horses and ponies and number of farms reporting horses or ponies were included in the study. Iowa and Idaho were excluded from the study due to expected resource conflicts with a then proposed NAHMS cattle on feed study. An additional seven states were included: Georgia, Maryland and New Jersey due to a high level of state equine industry interest; Alabama, Louisiana, New Mexico, and Wyoming to improve geographical representation.

A combination of NASS Area and List data sets, which provided estimates for the NASS January 1, 1998, inventory for all states in the U.S., formed the basis for selecting the sample for the Equine '98 study from the 28 target states. The Equine '98 sample selection is a sub-sample of the NASS Fall 1997 Area Survey and January 1998 Equine Survey respondents that reported one or more equids on hand on January 1, 1998. The sub-sampling was done within size groups based on total number of equids for list and area separately. Distribution of the sample to individual states was based primarily on the U.S. 1992 Census size indicator (previously discussed).

NASS enumerators initially contacted 4,311 operations from March 16 through April 10, 1998. The NAHMS Equine '98 baseline questionnaire was administered at each operation to collect health and management information. At the conclusion of the first interview, participants who had three or more horses present on January 1, 1998, were asked to participate in the next phase of the study.

Participants who agreed to participate in the second phase of the study were contacted by Federal and state VMO's and AHT's. The NAHMS Equine '98 VS phase initial questionnaire was administered during this second visit. In addition to general management questions, more in-depth information was sought on a variety of topics including parasites, vaccinations, lameness and equine protozoal myeloencephalitis.

The inverse of the probability of selection was used as the initial input weight and then adjusted for participation during the various phases of selection and non-response.

Terms Used in This Report

Average: The sum of all values divided by the number of values incorporated into the sum. The average is a measure of center of the observed data.

EPM: Equine protozoal myeloencephalitis, a serious neurologic condition of horses. For the purpose of the NAHMS Equine '98 study, horses were considered to have EPM whenever the owner/operator believed they developed *any* problems attributed to this condition while resident on the operation. Horses were considered to have a new occurrence of EPM if they were apparently normal prior to onset, even if they were thought previously to have had EPM.

Geometric mean: An alternative measure of the average calculated as the n^{th} root of the product of the observations.

Horse: For this study, a domestic horse that was at least 14 hands tall at the withers when full grown.

Incidence: The number of new cases believed to be EPM divided by the number of horses at risk of developing the disease during a specified time period.

Median: The middle value in a set of numbers that are arranged in numerical order.

Operation: An area of land managed as a unit by an individual, partnership, or hired manager.

Operation average: A single value for each operation is summed over all operations reporting divided by the number of operations reporting.

Percent horses: The total number of horses with a certain attribute divided by the total number of horses on all operations (or all operations within a certain category such as size or region) multiplied by 100.

Percent operations: The total number of operations with a certain attribute divided by the total number of operations multiplied by 100.

P-value: The probability of observing a value at least as extreme as the one observed given the data. All p-values were determined using weighted Chi-square or weighted linear regression where appropriate.

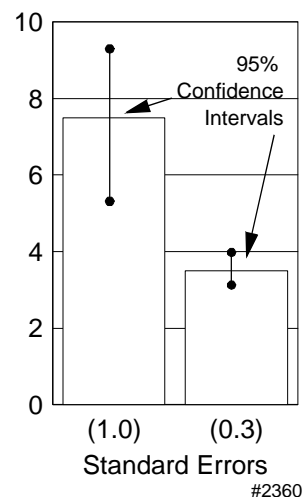
Population estimates: Averages and proportions weighted to represent the population. For this report, the reference population was all equine operations with three or more horses on January 1, 1998, in the 28 selected states. Estimates in this report are provided with a measure of precision called the **standard error**. A confidence interval can be created with bounds equal to the estimate plus or minus two standard errors. If the only error is sampling error, then confidence intervals created in this manner will contain the true population average 95 out of 100 times. In the example at right, an estimate of 7.5 with a standard error of 1.0 results in a range of 5.5 to 9.5 (two times the standard error above and below the estimate). The second estimate of 3.4 shows a standard error of 0.3 and results in a range of 2.8 and 4.0. Alternatively, the 90 percent confidence interval would be created by multiplying the standard error by 1.65 instead of two. Most estimates in this report are rounded to the nearest tenth. If rounded to 0, the standard error was reported as (0.0). If there were no reports of the event, no standard error was reported (--).

Quartile: Divide the population into four equal groups. Twenty-five percent will have a value of less than the 25th quartile. The 50th percentile is the middle value of the population.

Regions:

- **Western:** California, Colorado, Montana, New Mexico, Oregon, Washington, and Wyoming.
- **Northeast:** New Jersey, New York, Ohio, and Pennsylvania.
- **Southern:** Alabama, Florida, Georgia, Kentucky, Louisiana, Maryland, Oklahoma, Tennessee, Texas, and Virginia.
- **Central:** Illinois, Indiana, Kansas, Michigan, Minnesota, Missouri, and Wisconsin.

Examples of a 95% Confidence Interval



Resident horse: A horse that spent or was expected to spend more time at the operation than at any other operation. The operation was its home base.

Sample profile: Information that describes characteristics of the operations from which Equine '98 data were collected.

***Sarcocystis neurona*:** The parasite thought to most commonly cause EPM. It is important to realize that not all horses infected with this parasite develop EPM.

Signs of disease: Physical changes or symptoms exhibited by horses that are believed to be attributable to EPM.

Size of operation: Size groupings based on number of resident horses at the time of the initial VMO interview (April 20 - June 12, 1998). Size of operation was categorized as 1-5, 6-19, and 20 or more horses at the time of the interview. Although operations were required to have three or more horses or foals on January 1, 1998, to qualify for this (second) phase of the study, the horse population on the operation could have decreased to one horse or foal at the time of the interview.

Stocking density: Maximum number of horses per acre that was turned out at any one time in any one unit (e.g., paddock, pasture) during the summer of 1997.

Section I: Population Estimates

A. Familiarity with EPM

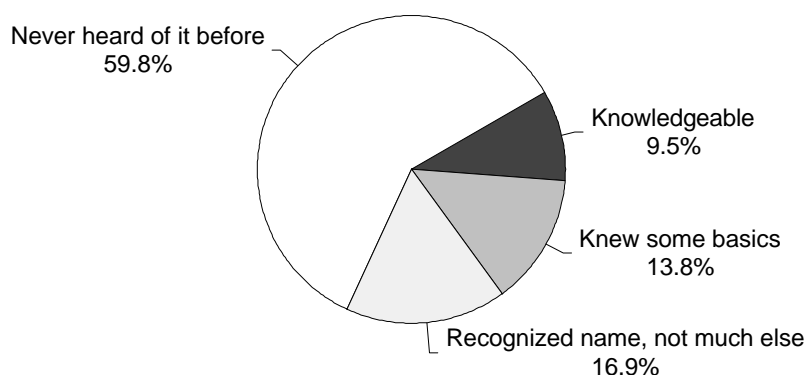
1. Region

Among all operations, 59.8 percent of owners/operators had never heard of equine protozoal myeloencephalitis or EPM at the time of the interview, 16.9 percent recognized the name but not much else, 13.8 percent knew some basics about the disease, and 9.5 percent considered themselves knowledgeable about EPM. There appeared to be differences in knowledge of EPM between the Western or Southern regions compared to the Northeast region, but there was no overall detectable difference in familiarity with EPM among different regions ($P = 0.07$).

a. Percent of operations by familiarity with the term EPM and region:

Owner/Operator Level of Familiarity	Percent Operations by Region									
	Southern		Northeast		Western		Central		All Operations	
	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error
Never heard of it before	62.0	(4.6)	49.0	(9.2)	67.3	(5.2)	52.9	(6.3)	59.8	(2.9)
Recognized the name, not much else	20.3	(4.0)	9.0	(3.8)	17.6	(3.7)	15.0	(4.3)	16.9	(2.1)
Knew some basics	12.0	(3.1)	19.4	(6.0)	11.1	(3.2)	16.9	(4.0)	13.8	(1.9)
Knowledgeable	<u>5.7</u>	(2.4)	<u>22.6</u>	(8.2)	<u>4.0</u>	(1.6)	<u>15.2</u>	(4.2)	<u>9.5</u>	(1.8)
Total	100.0		100.0		100.0		100.0		100.0	

Percent of All Operations by Familiarity with the Term EPM



#4250

2. Size of operation

There was a detectable difference in familiarity with EPM among operations by the number of resident horses present at the time of the interview ($P < 0.001$). Familiarity of owners/operators with EPM increased as the number of resident horses increased; the proportion of operations with some knowledge of EPM increased from 30.3 percent among those with one to five resident horses or foals to 68.7 percent among operations with 20 or more resident horses.

a. Percent of operations by familiarity with the term EPM and size of operation:

Percent Operations by Size of Operation (Number Resident Horses and Foals)

Owner/Operator Level of Familiarity	1-5		6-19		20 or More	
	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error
Never heard of it before	69.7	(3.8)	49.5	(4.6)	31.3	(6.6)
Recognized the name, not much else	13.9	(2.5)	20.9	(3.9)	21.7	(6.8)
Knew some basics	10.8	(2.5)	14.4	(2.9)	33.6	(6.8)
Knowledgeable	<u>5.6</u>	(1.9)	<u>15.2</u>	(3.9)	<u>13.4</u>	(4.0)
Total	100.0		100.0		100.0	

3. Primary use of resident horses

There was a detectable difference in familiarity among operations by the primary use of resident horses ($P < 0.001$). Owners/operators on operations where resident horses were used primarily for farming or ranching had by far the least familiarity with this disease; 77.1 percent had never heard of the condition and only 1.8 percent knew some basics or considered themselves knowledgeable about EPM. Owners/operators on operations where horses were used primarily for breeding were the most familiar with EPM; 22.0 percent considered themselves knowledgeable and 32.0 percent reported that they at least knew some basic information about EPM.

a. Percent of operations by familiarity with the term EPM and primary use of resident horses:

Percent Operations by Primary Use of Resident Horses

Owner/Operator Level of Familiarity	Pleasure		Showing/ Competition (Not Betting)		Breeding		Racing		Farm/Ranch		Other	
	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error
Never heard of it before	65.1	(4.2)	48.3	(6.8)	35.8	(6.9)	52.2	(17.0)	77.1	(5.4)	32.1	(20.8)
Recognized the name, not much else	16.5	(3.1)	23.0	(6.3)	10.2	(3.2)	0.7	(0.5)	21.1	(5.2)	42.8	(26.7)
Knew some basics	11.8	(2.3)	11.5	(3.9)	32.0	(6.9)	36.5	(16.3)	1.0	(0.9)	21.1	(17.0)
Knowledgeable	<u>6.6</u>	(2.0)	<u>17.2</u>	(6.0)	<u>22.0</u>	(6.8)	<u>10.6</u>	(8.4)	<u>0.8</u>	(0.7)	<u>4.0</u>	(2.5)
Total	100.0		100.0		100.0		100.0		100.0		100.0	

Note: If owners/operators responded that they had never heard of EPM before the interview (59.8 percent), no other questions were asked regarding this disease (see Table I.A.1).

B. General Characteristics of EPM on Operations

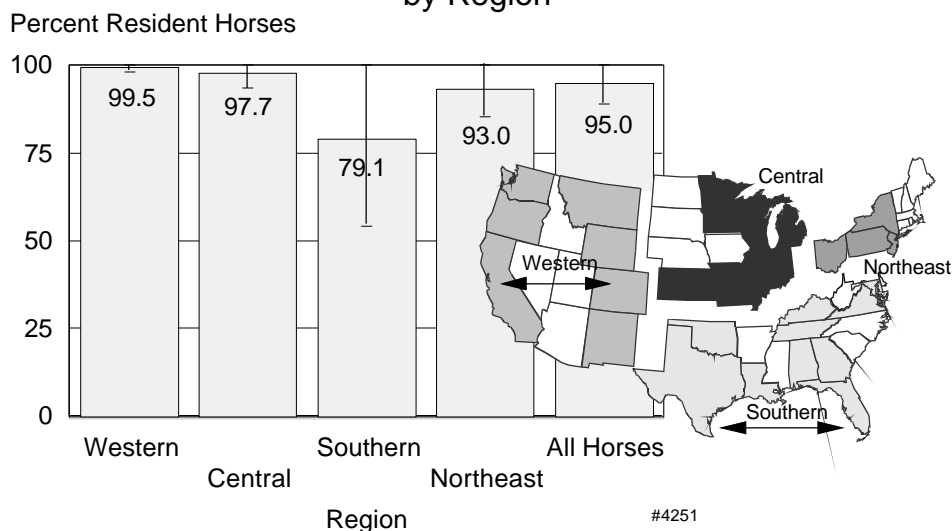
1. Veterinary diagnosis of EPM

Among EPM cases reported by owners/operators to have developed EPM during the previous year (March 1, 1997, through February 28, 1998), 95.0 percent were diagnosed by a veterinarian. There was no detectable difference in the proportion of EPM cases that were diagnosed reportedly by a veterinarian in the last year among operations in the different regions ($P = 0.34$). This finding suggests that disease reported in this study was based generally on veterinarians' diagnoses, despite being reported by owners/operators. It should be noted that this information refers only to cases occurring in the past year, and does not refer to all EPM cases ever diagnosed on operations.

a. For resident horses exhibiting signs during the last year (March 1, 1997, through February 28, 1998) believed to be EPM, percent of horses that were diagnosed with EPM by a veterinarian by region:

Percent Resident Horses by Region									
Southern		Northeast		Western		Central		All Horses	
Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error
79.1	(12.7)	93.0	(3.9)	99.5	(0.6)	97.7	(2.1)	95.0	(3.1)

For Resident Horses Exhibiting Signs Believed to be EPM, Percent that Were Diagnosed with EPM by a Veterinarian by Region



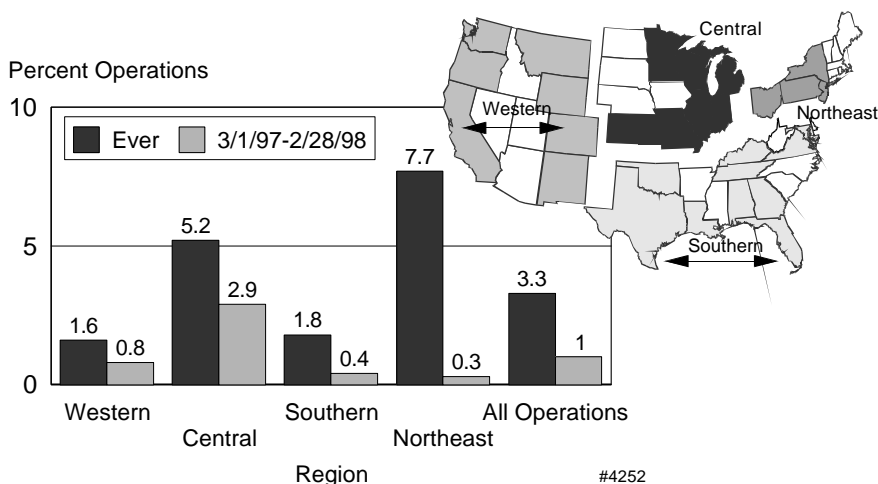
2. Region

Overall, 1.0 percent of operations reported that at least one resident horse developed EPM during the previous year (March 1, 1997, through February 28, 1998), and 3.3 percent of operations had at least one resident horse develop EPM at any time while the operation was in existence. Regional differences were detected in the occurrence of EPM on operations during the previous year ($P = 0.05$) and at any time during the operations' existence ($P = 0.02$). These regional differences in the likelihood of recognizing EPM on operations appear to have changed over time. During the previous year, operations in the Central region were most likely to report at least one occurrence of EPM (2.9 percent). However, regarding the occurrence of EPM at any time during an operation's existence, operations in the Northeast region were most likely to report at least one case (7.7 percent), followed by the Central region (5.2 percent). These regional patterns may have been affected by differences in detection efforts among regions over time.

a. Percent of operations that reported **any** resident horse with problems believed to be EPM by time period and by region:

Time Period	Percent Operations by Region									
	Southern		Northeast		Western		Central		All Operations	
	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error
Ever	1.8	(0.7)	7.7	(4.0)	1.6	(0.9)	5.2	(2.3)	3.3	(0.8)
March 1, 1997 - February 28, 1998	0.4	(0.1)	0.3	(0.1)	0.8	(0.6)	2.9	(2.0)	1.0	(0.5)

Percent of Operations that Reported ANY Resident Horse with Problems Believed to be EPM by Time Period and by Region



The annual incidence of EPM estimated among horses 6 months of age or older on operations represented by the study population was 14 new cases per 10,000 horses per year (SE=6 cases per 10,000 horses per year). Differences in the annual incidence of EPM were not detectable among operations from different regions ($P = 0.53$).

b. Percent of horses 6 months of age or older that developed problems believed to be EPM from March 1, 1997, through February 28, 1998, by region:

Percent Horses by Region									
Southern		Northeast		Western		Central		All Horses	
Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error
0.06	(0.02)	0.07	(0.02)	0.12	(0.08)	0.43	(0.29)	0.14	(0.06)

3. Size of operation

A greater proportion of operations with 20 or more resident horses recognized at least one EPM case compared to operations with fewer resident horses regardless of the time period being examined.

a. Percent of operations that reported **any** resident horse with problems believed to be EPM by time period and by size of operation:

Time Period	Percent Operations by Size of Operation (Number Resident Horses and Foals)							
	1-5		6-19		20 or More		All Operations	
	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error
Ever	2.0	(1.1)	3.4	(1.2)	12.5	(3.4)	3.3	(0.8)
March 1, 1997 - February 28, 1998	0.7	(0.7)	0.7	(0.6)	4.7	(2.2)	1.0	(0.5)

While operations with a larger number of resident horses were more likely to recognize at least one EPM case during the previous year (Table I.B.3.a.), differences in annual incidence of EPM were not detectable among operations with varying numbers of resident horses ($P = 0.58$).

b. Percent of horses 6 months of age or older that developed problems believed to be EPM from March 1, 1997, through February 28, 1998, by size of operation:

Percent Horses by Size of Operation (Number Resident Horses and Foals)							
1-5		6-19		20 or More		All Horses	
Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error
0.19	(0.19)	0.09	(0.07)	0.20	(0.08)	0.14	(0.06)

4. Primary use of resident horses

There were detectable differences in the occurrence of EPM, during the previous year as well as anytime during the operation's existence, among operations based on the category of the primary use of horses ($P < 0.001$). Operations where resident horses were used primarily for farm and ranch purposes had the lowest reported occurrence of EPM regardless of the time period being examined. The apparent differences seen among operations where horses had different primary uses may be attributable to differences in the likelihood of exposure to *S. neurona* and differences in rigor of monitoring for EPM.

a. Percent of operations that reported **any** resident horse with problems believed to be EPM by time period and by primary use of resident horses:

Percent Operations by Primary Use of Resident Horses

Time Period	Pleasure		Showing/ Competition (Not Betting)		Breeding		Racing		Farm/Ranch		Other	
	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error
Ever	2.1	(1.0)	4.1	(2.7)	9.7	(3.4)	6.0	(3.9)	0.1	(0.1)	2.9	(1.9)
March 1, 1997 - February 28, 1998	0.4	(0.3)	3.5	(2.7)	1.7	(1.4)	2.2	(1.3)	0.1	(0.1)	1.1	(0.7)

There were detectable differences in the annual incidence of owner/operator-reported EPM occurrence during the previous year (March 1, 1997, through February 28, 1998) among operations, based on the category of primary use of resident horses ($P = 0.04$). Operations where resident horses were used for pleasure or for farming/ranching had the lowest annual incidence (6 cases per 10,000 horses per year and 1 case per 10,000 horses per year, respectively). These rates were significantly lower than the annual incidence on operations where horses were used primarily for racing (38 cases per 10,000 horse per year, $P = 0.05$). While the estimated annual incidence of EPM was highest among operations where horses were used principally for showing or competition (not racing; 51 cases per 10,000 horses per year), there was marked variability in the annual incidence of EPM on this type of operation. These estimates may have reflected variability in detection efforts related to use of horses on the operations.

b. Percent of horses 6 months or older that developed problems believed to be EPM from March 1, 1997, through February 28, 1998, by primary use of resident horses:

Percent Horses by Primary Use of Resident Horses

Pleasure		Showing/ Competition (Not Betting)		Breeding		Racing		Farm/Ranch		Other		All Horses	
Percent	Stand. Error	Percent	Stand. Error	Percent	Stand. Error	Percent	Stand. Error	Percent	Stand. Error	Percent	Stand. Error	Percent	Stand. Error
0.06	(0.05)	0.51	(0.39)	0.17	(0.12)	0.38	(0.16)	0.01	(0.01)	0.17	(0.12)	0.14	(0.06)

5. Average number of cases of EPM per operation

Among operations where EPM had ever been recognized among resident horses, an average of 1.7 EPM cases per operation were reported. There was not a detectable difference in the average number of cases among operations according to the familiarity with EPM (excluding operations where the owner/operator had no prior knowledge of EPM) ($P = 0.14$).

- a. For operations that had ever had **any** resident horse that developed problems believed to be EPM, average number of cases **ever** on the operation by familiarity:

Owner/Operator Level of Familiarity	Average Number	Standard Error
Recognized the name, not much else	1.1	(0.1)
Knew some basics	1.7	(0.4)
Knowledgeable	1.8	(0.5)
All operations	1.7	(0.3)

For operations that reported the occurrence of EPM at any time while the operation was in existence, 77.0 percent reported recognizing only one case.

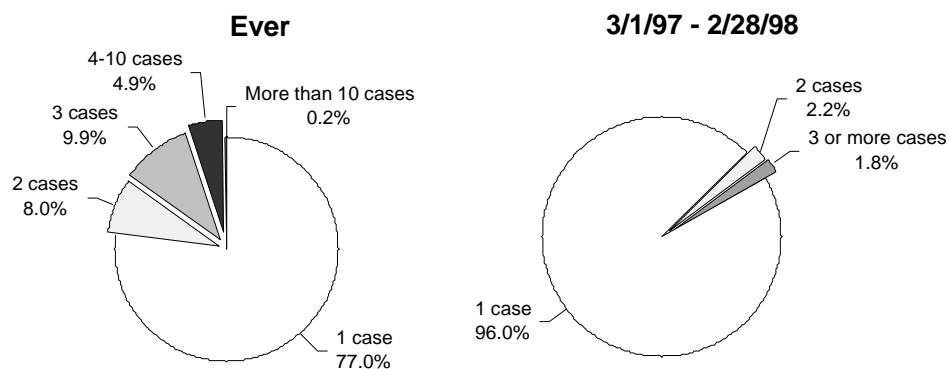
For operations that reported the occurrence of EPM during the previous year, only one case was reported to have occurred on 96.0 percent of operations.

- b. For operations that had ever had EPM, percent of operations by total number of EPM cases and by time period:

Percent Operations by Total Number of EPM Cases

Time Period	1		2		3		4 or More	
	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error
Ever	77.0	(9.6)	8.0	(5.2)	9.9	(8.1)	5.1	(3.4)
March 1, 1997 - February 28, 1998	96.0	(2.3)	2.2	(1.6)	0.8	(0.5)	1.0	(0.6)

Percent of Operations* by Total Number of Cases of EPM and by Time Period



*Among operations that had ever had ANY resident horse that developed problems with EPM.

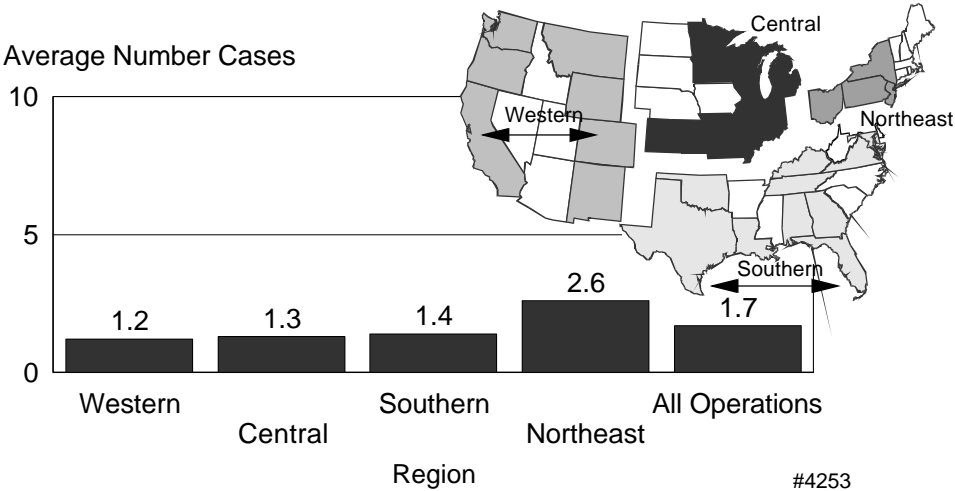
#4086

Among operations where EPM had been recognized among resident horses at any time while the operation was in existence, there was not a detectable difference in the average number of cases ever recognized among operations in the different regions ($P = 0.35$; Table B.5.b.i.) or among operations with different numbers of resident horses ($P = 0.86$; Table I.B.5.b.ii).

i. For operations that ever had **any** resident horse develop problems believed to be EPM, average number of cases **ever** recognized by region:

Average Number Cases by Region									
Southern		Northeast		Western		Central		All Operations	
Average	Standard Error	Average	Standard Error	Average	Standard Error	Average	Standard Error	Average	Standard Error
1.4	(0.2)	2.6	(1.0)	1.2	(0.1)	1.3	(0.2)	1.7	(0.3)

Average Number of Cases of EPM Ever Recognized on an Operation* by Region



*For operations that had ever had ANY resident horse that developed problems believed to be EPM.

Population: Operations in the 28 Equine '98 states with 3 or more horses on January 1, 1998

ii. For operations that ever had **any** resident horse develop problems believed to be EPM, average number of cases **ever** recognized by size of operation:

Average Number Cases by Size of Operation (Number Resident Horses and Foals)					
1-5		6-19		20 or More	
Average	Standard Error	Average	Standard Error	Average	Standard Error
1.5	(0.5)	2.0	(0.8)	1.7	(0.3)
All Operations		Average	Standard Error		
		1.7	(0.3)		

For Section C, the owners/operators were asked to provide information about horses that developed signs of EPM during the previous year (March 1, 1997, through February 28, 1998).

The following data refer to 0.14 percent of horses 6 months or older in the study population that developed signs of EPM in the last year (cases). All information was reported by owners/operators and not veterinarians. However, 95.0 percent of EPM cases reported to have developed during the previous year (March 1, 1997, through February 28, 1998) were diagnosed by a veterinarian (see Table I.B.1.a).

C. EPM Cases that Developed from 3/1/97-2/28/98

1. Season of onset

Onset of disease was most likely to occur in the summer and fall among EPM cases recognized during the previous year (82.0 percent). This pattern was also observed in the last case of EPM (Table I.D.1.a).

a. For resident horses with problems believed to be EPM, percent of cases by season of onset:

Time	Last Year (March 1, 1997, through February 28, 1998)	
	Percent Cases	Standard Error
Spring (March - May)	13.9	(6.6)
Summer (June - August)	40.8	(22.9)
Fall (September - November)	41.2	(20.3)
Winter (December - February)	4.1	(2.1)
Total	100.0	

Among all occurrences of EPM that were reported to *ever* have been identified on operations, 19.2 percent were reported to have occurred during the previous year, although this varied by region. Cases that were reported during the previous year represented only 2.7 percent of the total cases reported in the Northeastern region. In contrast, EPM cases reported during the previous year in the Western and Central regions represented about 44 percent of cases reportedly *ever* recognized. While there were detectable differences between regions, differences should be interpreted cautiously since the associated standard errors are relatively large.

b. Among all EPM cases ever recognized, percent of cases that occurred between March 1, 1997, through February 28, 1998, by region:

Percent Cases by Region									
Southern		Northeast		Western		Central		All Horses	
Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error
16.8	(6.4)	2.7	(1.1)	43.8	(22.9)	43.7	(22.2)	19.2	(7.8)

2. Method of diagnosis

Among the methods reported as being used to diagnose EPM on the operation in the previous year, clinical signs were used most commonly (60.3 percent), followed by serology (47.1 percent), cerebrospinal fluid (CSF) analysis (31.7 percent), and response to treatment (6.9 percent). Methods reported in the "other" category included use of radiography potentially to rule out other neurologic diseases. Postmortem examination has been considered by many to be the most definitive method of diagnosing EPM, however this method was used in less than 1 percent of cases. These categories were not mutually exclusive and more than one method could have been used to diagnose EPM in any given horse.

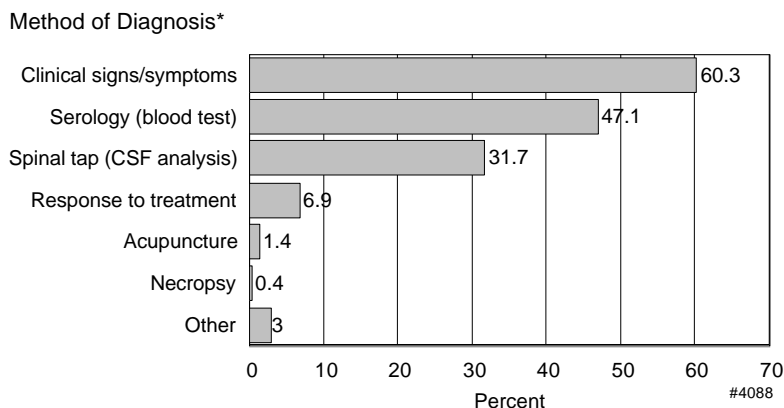
NOTE: All information was reported by equine owners/operators and may not reflect veterinarians' opinions or preferred method of diagnoses.

a. Percent of resident horses with problems believed to be EPM diagnosed in the last year (March 1, 1997, through February 28, 1998) by method of diagnosis:

Method of Diagnosis*	Percent	Standard Error
Clinical signs or symptoms	60.3	(22.8)
Response to treatment	6.9	(3.4)
Serology (blood test)	47.1	(21.4)
Spinal tap (CSF analysis)	31.7	(17.5)
Acupuncture	1.4	(0.9)
Necropsy	0.4	(0.3)
Other	3.0	(2.6)
Unknown	0.0	(0.0)

*These categories were not mutually exclusive and more than one method could have been used to diagnose EPM in any given horse.

Percent of Horses with Problems Believed to be EPM Diagnosed in the Last Year
March 1, 1997, through February 28, 1998, by Method of Diagnosis*



*These categories were not mutually exclusive and more than one method could have been used to diagnose EPM.

3. Clinical signs

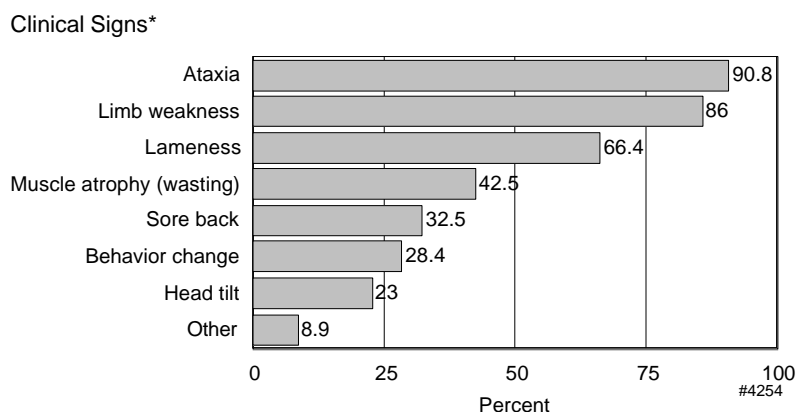
The most common clinical signs reportedly seen among horses with EPM during the last year were ataxia (90.8 percent of cases), limb weakness (86.0 percent), lameness (66.4 percent), muscle atrophy (42.5 percent), back soreness (32.5 percent), behavior change (28.4 percent), and head tilt (23 percent). Signs reported in the “other” category included gait abnormalities, weight loss, and other neuromuscular problems, such as muscle twitching. These categories were not mutually exclusive and a horse could have exhibited more than one sign.

a. For resident horses with problems believed to be EPM diagnosed in the last year (March 1, 1997, through February 28, 1998), percent of resident horses with the following clinical signs:

Clinical Signs*	Percent	Standard Error
Ataxia (wobbly, uncoordinated)	90.8	(4.7)
Head tilt	23.0	(14.6)
Head shaker	3.7	(2.2)
Seizures	2.3	(1.4)
Lameness	66.4	(16.6)
Limb weakness	86.0	(6.8)
Peripheral nerve deficit (droopy ear, muzzle pulled to one side)	0.9	(0.6)
Muscle atrophy (wasting)	42.5	(20.1)
Roarer (makes roaring noise when exercised)	0.9	(0.6)
Drooling or inability to swallow	1.2	(0.6)
Behavior change	28.4	(17.2)
Sore back	32.5	(17.6)
Other	8.9	(4.7)

*These categories were not mutually exclusive and a horse could have exhibited more than one sign.

Percent Resident Horses with EPM Diagnosed in the Last Year
(March 1, 1997, through February 28, 1998) with the Following
Clinical Signs*



*These categories were not mutually exclusive and a horse could have exhibited more than one sign.

4. Treatment

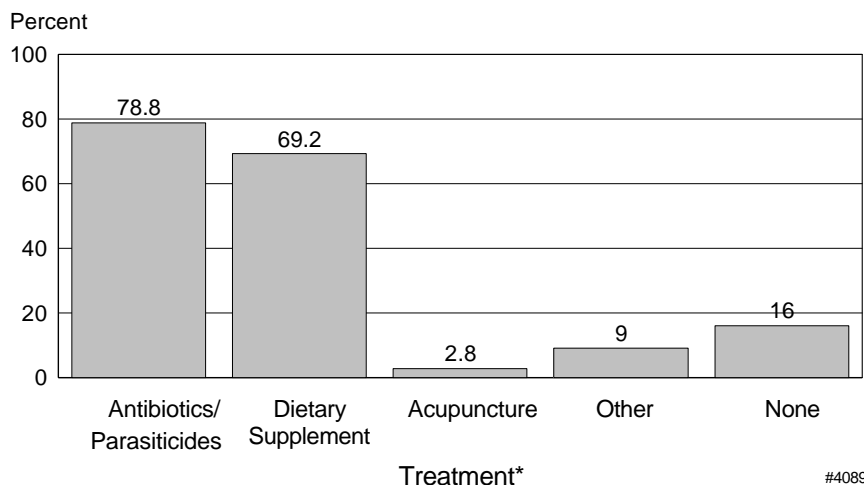
Among horses with problems believed to be EPM during the last year, 16.0 percent reportedly received no treatment, 78.8 percent received an antibiotic or parasiticide, and 69.2 percent received a dietary supplement (e.g., vitamins) to treat the EPM. The most common treatments administered to horses with EPM in the “other” category were anti-inflammatory medications including flunixin meglumine, phenylbutazone, and dimethylsulfoxide (DMSO). Treatment categories were not mutually exclusive and a horse could have received more than one type of treatment.

a. For resident horses with problems believed to be EPM in the last year (March 1, 1997, through February 28, 1998), percent of resident horses by treatment:

Treatment*	Percent	Standard Error
Antibiotics or parasiticide	78.8	(14.7)
Acupuncture	2.8	(1.9)
Dietary supplement, such as folic acid or vitamin E	69.2	(16.2)
Other	9.0	(4.7)
None	16.0	(14.0)

*These categories were not mutually exclusive and a horse could have received more than one type of treatment.

**Percent Resident Horses with Problems Believed to be EPM
in the Last Year (March 1, 1997, through February 28, 1998)
by Treatment***



*These categories were not mutually exclusive and a horse could have received more than one type of treatment.

#4089

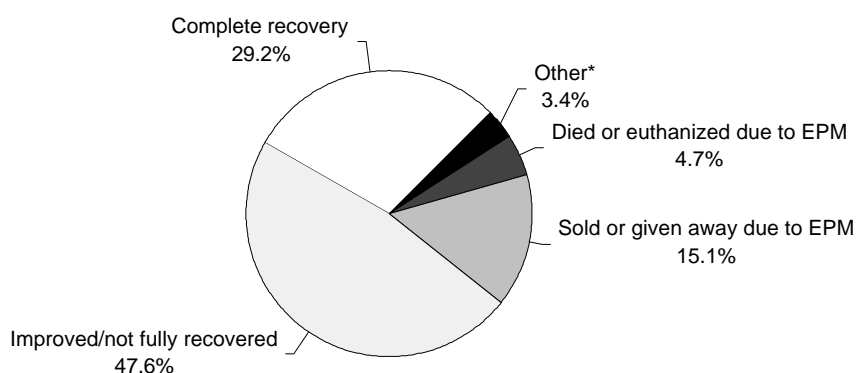
5. Outcome

Among horses with problems believed to be EPM recognized during the last year, the majority were reported to have recovered completely (29.2 percent) or to have improved but not fully recovered (47.6 percent). Only 4.7 percent of horses diagnosed with EPM during the previous year died or were euthanatized, but 15.1 percent were sold or given away because of this condition. Of the 1.5 percent of these EPM cases that reportedly had other outcomes, about one-half were reported to have died due to other causes, such as colic, and the outcome was unknown for the other one-half because the horse was sold or given away for reasons reportedly unrelated to EPM.

a. For resident horses with problems believed to be EPM in the last year (March 1, 1997, through February 28, 1998), percent of horses by outcome:

Outcome	Percent	Standard Error
Complete recovery	29.2	(17.2)
Improved but not fully recovered	47.6	(21.4)
Improved or complete recovery followed by relapse	0.8	(0.6)
No response after at least 3 months duration	1.0	(0.6)
No response, but case is less than 3 months duration	0.1	(0.1)
Died or euthanatized due to EPM	4.7	(2.9)
Sold or given away due to EPM	15.1	(13.8)
Other	<u>1.5</u>	(1.5)
Total	100.0	

Percent of Resident Horses with Problems Believed to be EPM in the Last Year (March 1, 1997, through February 28, 1998) by Outcome



*No response after at least 3 months duration (1.0%)
Improved or complete recovery followed by relapse (0.8%)
No response, but case was less than 3 months duration (0.1%)
Other (1.5%).

#4256

For Section D, owners/operators were asked to provide detailed information regarding the last case of EPM to have developed on the operation regardless of when the onset of disease occurred. Information was requested regarding this single last case as it was thought that recall would be most accurate for this horse, and it would be less difficult than reporting detailed information regarding every EPM case that ever occurred on the operation.

D. Description of Last Cases of EPM

1. Season of onset

Onset of disease was most likely to occur in the summer and fall among the last cases of EPM (66.9 percent). This pattern was also observed in cases of EPM during the previous year (Table I.C.1.a).

a. For resident horses with problems believed to be EPM, percent of cases by time of onset:

Time	Last EPM Case	
	Percent Cases	Standard Error
Spring (March - May)	18.0	(8.8)
Summer (June - August)	36.1	(13.7)
Fall (September - November)	30.8	(11.0)
Winter (December - February)	15.1	(7.1)
Total	100.0	

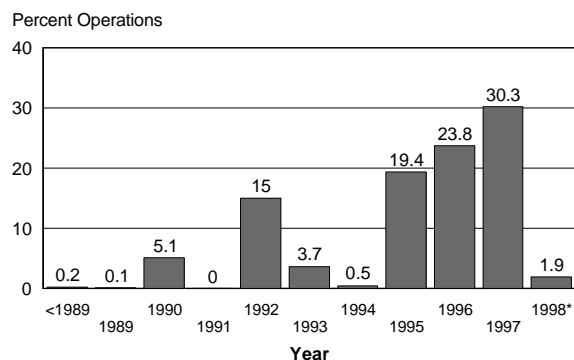
2. Year of onset

Over one-half (56.0 percent) of the EPM cases described as the last case to occur on operations were reported to have occurred within 2 years of the interview (1996 to spring 1998), and 94.6 percent were reported to have occurred since 1991. Likely, these findings were affected by increased awareness and increased surveillance for EPM that occurred after 1991 when diagnostic tests first became available commercially. While a small number of last cases were reported to have occurred in 1998, it should be noted that this finding only reflects cases recognized between January 1, 1998, and the date of the Equine '98 interview (held during the period April 20 through June 12, 1998).

a. For operations where any resident horses ever developed problems believed to be EPM, percent of operations by year of onset for the last case believed to be EPM:

Year	Percent Operations	Standard Error
1998*	1.9	(0.8)
1997	30.3	(11.9)
1996	23.8	(10.5)
1995	19.4	(8.4)
1994	0.5	(0.4)
1993	3.7	(3.3)
1992	15.0	(12.5)
1991	0.0	(0.0)
1990	5.1	(5.0)
1989	0.1	(0.1)
Before 1989	0.2	(0.2)
Total	100.0	

Percent of Operations Where Any Resident Horses Had EVER Developed Problems Believed to be EPM by Year of Onset for Last Case* of EPM



*As of Equine '98 interview (April 20 through June 12, 1998).

* As of Equine '98 interview (April 20 - June 12, 1998).

#4090

3. Method of diagnosis

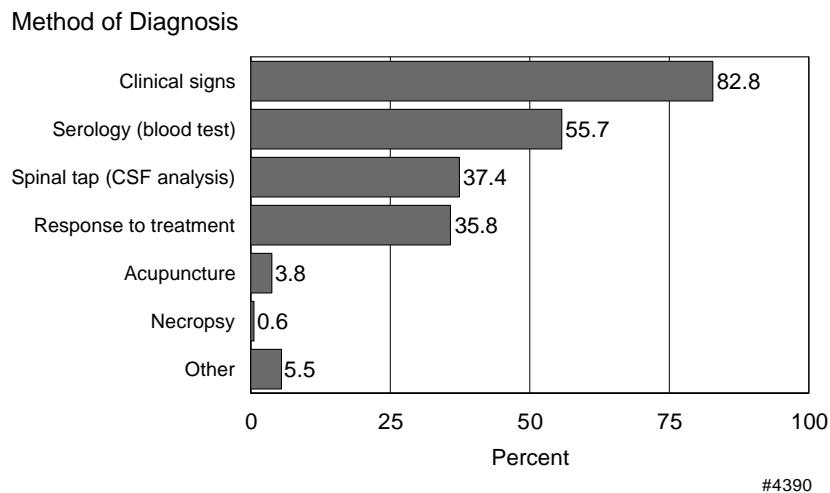
Among the methods reported by owners as being used to diagnose the last case of EPM recognized on premises, presence of clinical signs was used most commonly (82.8 percent), followed by use of serology (55.7 percent), cerebrospinal fluid (CSF) analysis (37.4 percent), and response to treatment (35.8 percent). This pattern held true generally regardless of the time period when this case was recognized. Reportedly clinical signs were used to diagnose almost all (99.6 percent) last cases recognized from 1992 through 1996 and were used less commonly in last cases recognized in 1997 and 1998. Differences should be interpreted with caution as standard error estimates were relatively large. Methods reported in the "other" category included use of radiography, potentially to rule out other neurologic diseases, and sending horses to a veterinary hospital for unspecified diagnostic evaluation. These categories were not mutually exclusive and more than one method could have been used to diagnose EPM.

a. Percent of last cases of EPM by method of diagnosis and by year of onset (1992 - February 28, 1998):

Method of Diagnosis	Percent of Last Cases by Year of Onset					
	1992-1996		1997-1998		All Last Cases*	
	Percent Cases	Standard Error	Percent Cases	Standard Error	Percent Cases	Standard Error
Clinical signs or symptoms	99.6	(0.3)	62.4	(24.8)	82.8	(11.1)
Response to treatment	39.9	(15.8)	30.0	(18.5)	35.8	(11.6)
Serology (blood test)	63.2	(14.9)	48.6	(22.6)	55.7	(12.2)
Spinal tap (CSF analysis)	43.7	(16.1)	33.5	(18.9)	37.4	(11.6)
Acupuncture	5.1	(4.6)	2.3	(1.5)	3.8	(2.9)
Necropsy	0.6	(0.5)	0.7	(0.4)	0.6	(0.4)
Other	0.5	(0.5)	0.5	(0.4)	5.5	(5.0)

*Includes cases prior to 1992.

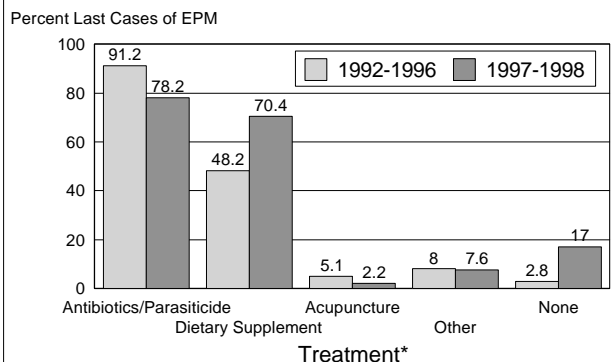
Percent of Last Cases of EPM by Method of Diagnosis



4. Treatment

Among horses described as the last case of EPM to occur on premises, 12.2 percent received no treatment, 83 percent received antibiotic or parasiticide drugs, and 51.8 percent received a dietary supplement, e.g., vitamins. Horses rarely were treated using acupuncture, and other treatments were administered reportedly to about 9 percent of the cases. The most common "other" treatment administered to horses with EPM were anti-inflammatory medications including flunixin meglumine, phenylbutazone, and DMSO. These treatment categories were not mutually exclusive and a horse could have received more than one treatment.

Percent of Last Cases of EPM
by Treatment(s) Used and by Year of Onset



*Treatments were not mutually exclusive.

#4091

a. Percent of last cases of EPM by treatments used and by year of onset (1992 - February 28, 1998):

Treatments Used	Percent of Last Cases by Year of Onset					
	1992-1996		1997-1998		All Last Cases*	
	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error
Antibiotics or parasiticide (I661)	91.2	(5.7)	78.2	(15.5)	83.0	(7.8)
Acupuncture (I663)	5.1	(4.7)	2.2	(1.5)	3.8	(2.9)
Dietary supplement, such as folic acid or vitamin E	48.2	(16.4)	70.4	(16.8)	51.8	(12.7)
Other	8.0	(5.7)	7.6	(4.4)	8.9	(4.2)
None	2.8	(1.4)	17.0	(14.9)	12.2	(6.9)

*Includes cases prior to 1992.

Among horses described as the last case of EPM that were treated with antibiotics or a parasiticide (excluding horses reported to have had no response but duration of illness was less than 3 months), the average treatment period was 111.3 days overall, and 140.4 days in horses whose onset was between 1992 and 1996. While horses whose disease signs were recognized in 1997 and 1998 on average were treated for fewer days, this may be reflective of a shorter amount of time available between the initiation of treatment and the dates of interviews or an actual change in treatment duration.

b. For last cases of EPM treated with antibiotics or parasiticides (excluding horses reported to have had no response but duration of illness was less than 3 months), average duration in days of treatment by year of onset:

Average Treatment Duration (Days) by Year of Onset							
Prior to 1992		1992-1996		1997-1998		All Last Cases	
Average	Standard Error	Average	Standard Error	Average	Standard Error	Average	Standard Error
28.9	(12.5)	140.4	(36.0)	61.5	(26.1)	111.3	(26.9)

5. Outcome

Overall, among horses described as the last case of EPM occurring on premises, owners/operators reported that 39.7 percent recovered completely and 37.4 percent improved but were not completely recovered. The difference in the percentages of recovery among cases that developed in 1992 through 1996 and those that developed in 1997 through 1998 is possibly attributable to the shorter elapsed time between the onset of disease and the dates of interviews.

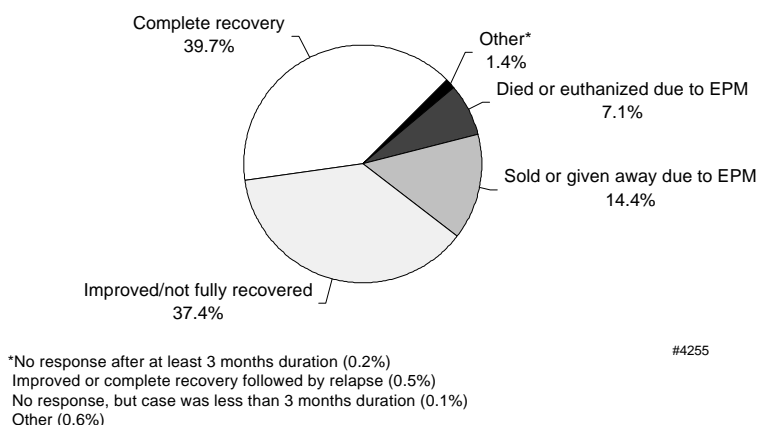
Overall, 14.4 percent of the last cases of EPM were sold or given away because of EPM, and 7.1 percent died or were euthanatized because of EPM. Of the 0.6 percent of the last EPM cases that reportedly had other outcomes, about one-half were reported to have died due to other causes, such as colic. Outcome was unknown for about half of the "other outcome" cases because the horse was sold or given away for reasons reportedly unrelated to EPM.

a. Percent of last cases of EPM by outcome of last case and year of onset (1992 through February 1998):

Outcome	Percent of Last Cases of EPM					
	1992-1996		1997-1998		All Last Cases*	
	Percent	Standard Error	Percent	Standard Error	Percent	Standard Error
Complete recovery	49.5	(16.7)	29.0	(18.3)	39.7	(13.0)
Improved but not completely recovered	24.2	(13.8)	50.0	(22.4)	37.4	(12.5)
Improved or complete recovery followed by relapse	0.8	(0.8)	0.1	(0.1)	0.5	(0.5)
No response after at least 3 months	0.2	(0.2)	0.4	(0.2)	0.2	(0.1)
No response but disease was less than 3 months in duration	NA	--	0.6	(0.4)	0.1	(0.1)
Sold or given away due to EPM	15.0	(9.8)	16.1	(14.8)	14.4	(7.6)
Died or euthanatized due to EPM	9.6	(5.3)	3.3	(2.0)	7.1	(3.3)
Other outcome	<u>0.7</u>	(0.4)	<u>0.5</u>	(0.4)	<u>0.6</u>	(0.3)
Total	100.0		100.0		100.0	

*Includes cases prior to 1992.

Percent of Last Cases of EPM by Outcome



6. Lost use

Among horses described as the last case of EPM occurring on the operation that were reported to have survived and were not lost to follow-up (i.e., those that recovered completely, improved but did not fully recover, relapsed following improvement or recovered completely, or showed no response after at least 3 months of duration of disease), owners/operators reported that about 10 percent had 0 days lost use.

a. Percent of horses described as the last case of EPM on operations that had 0 days of lost use reported and that were reported to have recovered completely, improved but did not fully recover, relapsed following improvement or recovered completely, or showed no response after at least 3 months duration of the disease:

Percent Last Cases with 0 Days of Lost Use	Standard Error
9.9	(6.4)

Among those last cases of EPM with at least 1 day of lost use reported, the median number of days of lost use attributed to illness related to EPM was 150 days (range 2 to 725 days). Twenty-five percent of these horses had fewer than 91 days of lost use, and 75 percent of these horses had fewer than 241 days of lost use. “Days of lost use” were defined as the number of days an affected horse could not be used for the purpose it was intended from the time disease was first identified.

b. Quartiles of reported days of lost use for last case of EPM on operations among those that had at least 1 day of lost use and had the following outcomes: recovered completely, improved but did not fully recover, relapsed following improvement or complete recovery, or showed no response after at least 3 months duration of the disease:

Quartiles	Number Days
0 - 25%	2 - 90 days
26 - 50%	91 - 150 days
51 - 75%	151 - 240 days
76 - 100%	241 - 725 days

Among horses described as the last EPM cases that survived and had follow-up (i.e., those that recovered completely, improved but did not fully recover, relapsed following improvement or complete recovery, or showed no response after at least 3 months of duration of disease), an average of 244 days of lost use was attributed to illness related to EPM. This number is different from the median (Table I.D.6.b) as the data were not normally distributed.

- c. For last cases of EPM, average number of days of lost use for horses with the following outcomes: recovered completely, improved but did not fully recover, relapsed following improvement or complete recovery, or showed no response after at least 3 months duration of the disease:

Average Lost Use (in Days)	Standard Error
244	(46)

For operations where at least one case of EPM had been identified at any point in the operations' history, the median number of years that horses were kept continuously on the operation was 20.0 years (average=18.5 years, SE=1.9 years). There was no detectable difference between operations where EPM had been detected previously and between those where EPM had not been detected in the average number of years horses were kept continuously on the operations ($P = 0.94$).

- d. For operations where at least one case of EPM had been identified in the operation's history, quartiles for the average number of years that horses were kept continuously on operations:

Quartiles	Number Years
0 - 25%	1 - 12.5 years
26 - 50%	13 - 20 years
51 - 75%	21 - 30 years
76 - 100%	31 - 190 years

Among horses described as the last case of EPM occurring on premises that were reported to have died or were euthanatized because of EPM, an average of 9.2 years (3,345 days) of lost use was attributed to illness related to EPM. The horse's age at death was subtracted from an assumed average life span of 20 years for calculation of lost use due to death from EPM.

- e. For last cases that died due to EPM, average number of years of lost use:

Average Lost Use (in Years)	Standard Error (in Years)
9.2	(1.5)

7. Cost of diagnostic testing, veterinary care, and medication

For horses described as the last case of EPM occurring on operations and whose disease was greater than 3 months in duration at the time of the Equine '98 interview (April 20 through June 12, 1998), the median cost of diagnostic testing, veterinary care, and medications, through the day of the Equine '98 interview was \$1,000 (range 0 to \$10,000). Owners/operators reported that less than \$301 was spent on 25 percent of these horses and less than \$1,501 was spent on 75 percent of horses. Less than 1 percent of owners/operators reported spending 0 dollars.

a. Quartiles for the reported cost of diagnostic testing, veterinary care, and medications for the last case of EPM on operations, excluding cases less than 3 months duration:

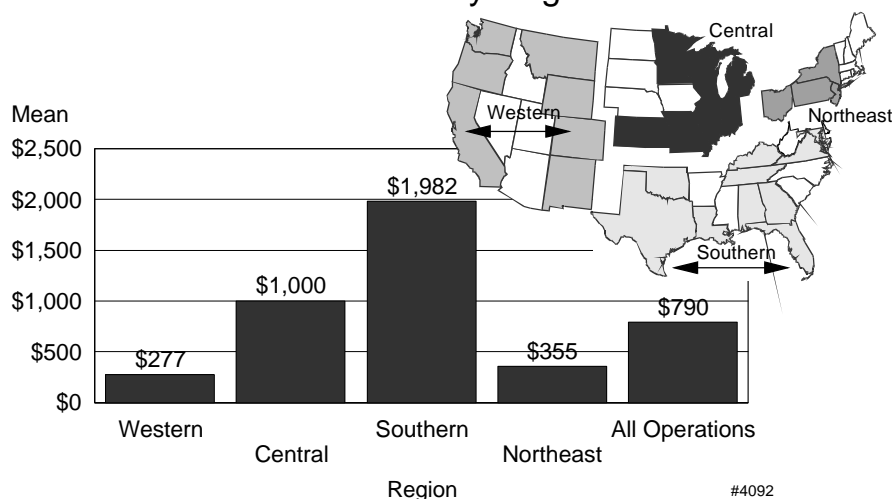
Quartiles	Cost (Dollars)
0 - 25%	\$0 - \$300
26 - 50%	\$301 - \$1,000
51 - 75%	\$1,001 - \$1,500
76 - 100%	\$1,501 - \$10,000

Overall, among horses described as the last case of EPM occurring on premises where disease was greater than 3 months in duration at the time of the interviews, the geometric mean for reported costs of diagnostic testing, veterinary care, and medications through the day of the Equine '98 interview was \$790. This amount varied by region ($P < 0.01$). The Southern region had the highest costs followed by the Central region. The Northeast and Western regions had similarly low costs ($P < 0.11$). However, there was a great deal of variability in reported costs (\$0 to \$10,000). This variation probably reflects differences in treatments, although it may also reflect accuracy of owner/operator recollections and the time lapsed from the disease event to the interview. Geometric means are reported because the data were not normally distributed.

b. Geometric mean cost of diagnostic testing, veterinary care, and medications for the last case of EPM through the day of the Equine '98 interview, excluding cases less than 3 months duration by region:

Region	Geometric Mean Cost (Dollars)	95% Confidence Interval	
		Lower Limit	Upper Limit
Southern	\$1,982	\$1,638	\$2,400
Northeast	\$355	\$324	\$389
Western	\$277	\$207	\$369
Central	\$1,000	\$953	\$1,049
All operations	\$790	\$741	\$843

Geometric Mean of Cost of Diagnostic Testing, Veterinary Care, and Medications for the Last Case of EPM* by Region



*Through the day of Equine '98 interview (April 20-June 12, 1998). Excludes cases of less than 3 months duration.

Section II: Discussion

A. Quality of Information

For the purposes of this study, resident horses were assumed to have had EPM during specified time periods if owners/operators believed they developed clinical problems that were associated with EPM. Testing for *S. neurona* infection was not sufficient for horses to have been considered a case. The owner/operator had to be confident that horses had clinical EPM, but this diagnosis did not have to be confirmed by a veterinarian. However, 95 percent of cases recognized during the previous year were diagnosed reportedly by veterinarians, which suggests that data collected regarding clinical information was generally reflective of veterinarians' diagnoses.

Case definition and methods used to diagnose disease deserve critical consideration before interpreting results of this study, as for any study. While other investigative methods may have been employed to identify EPM, this study provides the best information available to date regarding the occurrence of this disease in the nation as a whole. Currently there is tremendous controversy regarding the reliability of methods used to diagnose EPM, and there is no diagnostic protocol available that will yield uniformly reliable definitive diagnosis when applied to all horses believed to have EPM. This lack of universally accepted methods for making a definitive diagnosis makes it difficult to study EPM. Potentially, the more subjective, judgment based, case definition used in this study was as useful as other criteria based definitions that might have been employed. It would be extremely difficult and expensive, if not impossible, to perform a study of this magnitude using more rigorous attempts to definitively diagnose EPM (for example, neurologic examination by study personnel on a national basis).

This study concentrated on gathering information regarding horses diagnosed with EPM during the year prior to interviews, and regarding the last case of EPM recognized on the operation. It was thought that sufficient detail would be remembered from these occurrences of disease to minimize the problem of recall bias. This assumption is supported by the observation that 56 percent of last cases were recognized within 2 years of the interview (1996 or later), and 94 percent were recognized within 6 years of the interview (1992 or later). Another potential problem is the dramatic change in the understanding and surveillance for EPM during the past 15 years. However, data collected regarding those cases recognized in the last year should not have been affected as much by the rapid changes in surveillance, diagnostic, and treatment modalities.

Data gathered during VMO or AHT interviews also suggested that good quality information was obtained from this study. The personnel conducting interviews reported that there was little or no question about the validity of responses from 82 percent of operators interviewed, and an additional 17 percent of operators had adequate knowledge of the operation and their responses were based upon their best and earnest recollections even though written records were not consulted during interviews.

B. Occurrence of EPM in the United States

Information gathered during this study suggest that approximately 14 new occurrences of EPM were recognized during the year prior to interviews per 10,000 horses (14 cases per 10,000 horses per year SE=6 cases). These new occurrences could include disease recognized in horses that apparently had recovered from prior EPM episodes, but could not include disease occurring in horses diagnosed previously with EPM unless, according to owner/operators, they had recovered completely. Many experts believe that this disease has been recognized with increasing frequency in the recent past, but this may be attributable

to increased awareness and surveillance rather than increasing incidence. This study provides the first nationwide estimate of the incidence of EPM, so it is not possible to draw objective conclusions about trends in disease incidence. The method of classifying animals' disease status may have affected the accuracy of this incidence estimate. Considering the publicity and attention that this disease has received in the recent past, and the case definition that was employed for the study, it seems that disease incidence was more likely to have been overestimated to some degree, rather than underestimated.

Overall, 1.0 percent of operations reported the occurrence of EPM during the previous year, and 3.3 percent reported recognizing at least one case at any point during the operation's history, but there were detectable differences over time among regions. Operations in the Northeast region were more likely to recognize the occurrence of EPM at any time during their history, but operations in the Central region were more likely to recognize this disease during the past year. Little is known about the natural history of this disease and these apparent differences are possibly attributable to changing awareness and detection efforts rather than true variation in disease occurrence. Interestingly, there were not detectable differences in the regional estimates of EPM incidence among individual horses during the previous year. This finding suggests that the differences in the proportion of operations which recognized EPM are related to differences in numbers of horses at risk of developing EPM (Table I.B.3.a). Seroprevalence information is available currently only from a limited number of states and it is therefore not possible to compare reported frequency of disease occurrence with rates of exposure to *S. neurona*.

Results of this study suggest that veterinarians play a major role in the diagnosis of EPM (Table I.B.1). While evaluation of clinical signs or symptoms was the most common diagnostic method reported, overall, owners/operators reported that there was a decrease over time in the use of clinical signs; clinical signs were only used in the diagnosis of about 60 percent of cases reported to have developed in the previous year. It must be considered, however, that this information was reported by owners/operators and not veterinarians. Also, serology and spinal fluid analysis were used commonly to diagnose EPM. It has been reported previously that methods that can be used to make a definitive diagnosis of this disease include postmortem histological examination of central nervous system (CNS) tissues (preferably including immunodiagnostic methods), Western blot evaluation of cerebral spinal fluid (CSF), identification of specific neurologic abnormalities, and response to treatment.⁴⁻⁶ Serology can be used to document exposure to parasites thought to cause EPM, but horses apparently can be exposed frequently without ever developing clinical disease. While necropsy with subsequent postmortem histologic examination of neurologic tissues by qualified pathologists is probably the most specific method of diagnosis of EPM, this method is expensive and may lack sensitivity. These drawbacks may be reflected in the use of postmortem evaluation in the diagnosis of less than 1 percent of horses reported to have developed EPM, even though 4.7 percent of cases recognized during the previous year and 7.1 percent of the last cases recognized died or were euthanatized because of EPM (Tables I.C.2.a, I.C.5.a, I.D.3.a, I.D.5.a).

The majority of horses with EPM reportedly were treated with antimicrobial or parasiticide drugs, and with dietary supplements (Tables I.C.4.a, I.D.4.a). It is worth noting that many horses with EPM were reportedly not treated (16.0 percent of horses diagnosed during the previous year, and 12.2 percent of the last cases of EPM). Unfortunately, the study design did not allow determination of the outcome of these particular cases with confidence. The use of acupuncture to diagnose or treat EPM has been advocated by some veterinarians and horse owners, but the validity and efficacy of this practice has been questioned.⁴⁴ Findings from this study suggest that acupuncture is not used commonly for either purpose in the U.S (Tables I.C.2.a, I.C.4.a, I.D.3.a, I.D.4.a).

Administration of antifolate medications including sulfadiazine and pyramethamine was the first recommended therapy for EPM. This treatment was based originally on histologic resemblance of *S. neurona* to *Toxoplasma gondii*, and extrapolation from recommended treatment of toxoplasmosis in humans.^{46,47}

These medications are still used commonly to treat horses with EPM, but there have been frequent changes in recommended dosages, treatment frequency, treatment duration, product formulations, and ancillary treatments. In addition, treatment with triazine derivative parasiticides has become increasingly common since about 1997.³⁴⁻⁴² These changes in recommended treatment have been based empirically, and unfortunately there are no published studies evaluating differences in treatment efficacy. Among horses reported to have developed EPM during the previous year, 29.2 percent were reported to have completely recovered by the time of the interview, and 47.6 percent were improved but not completely recovered. In comparison, among last cases of EPM that developed between 1992 and 1996, about 50 percent were reported to have complete recovery and 24.2 percent were improved but not completely recovered. Apparent differences in recovery rates identified during this study should be interpreted with caution as standard errors associated with these estimates were relatively large (Tables I.C.5.a, I.D.5.a). The magnitude of variation in these estimates likely was influenced by differences in the amount of time that elapsed between recognition of disease and interviews which took place between April 20 and June 12, 1998. Estimates of recovery identified in this study are similar to previously reported estimates that clinical improvement can be expected in about 70 percent of treated horses.^{4-6,47,48} It should also be noted that the way in which this question was worded may have affected this result; horses that improved, but were sold or euthanatized because of EPM would likely not be listed in the categories denoting improvement in horses' conditions. Only about 1 percent of cases that developed during the previous year were described as showing no improvement after at least 3 months duration, as were fewer than 1 percent of all last cases, but this also excludes horses that died or were given away due to EPM.

It has been reported that some horses with EPM develop a worsening of clinical disease after cessation of treatment (a relapse). These relapses have been suggested to occur in 5 to 28 percent of cases.^{5,37,48,49}

While clinical improvement or complete recovery followed by relapse in disease signs was reported to have occurred in less than 1 percent of EPM cases regardless of the year that disease was recognized, this may be influenced by the manner in which cases were defined for this study. For the purposes of this study, horses were considered to have a new occurrence of disease if they were clinically normal prior to its onset, even if they were thought to have previously had EPM.

The duration of drug use required to treat horses effectively with EPM is a controversial issue, and clinical trials that would provide objective information to clarify this issue have, to date, not been published. Some authors have proposed that horses should be treated for 60-90 days beyond when antibody to *S. neurona* is undetectable in the CSF, or 2 to 4 weeks past resolution or stabilization of clinical abnormalities.^{50,51} In this study, among the last cases of EPM recognized on operations, cases that developed between 1992 and 1996 were treated for an average of 140.4 days while those recognized during the previous year (1997 to 1998) were treated for an average of 61.5 days. The difference between these averages may be affected by differences in drugs used and recommended treatment protocols. It is also possible that these estimated differences could have been affected by differences in the elapsed time between recognition and the interview dates for the two periods. In comparison, a recent epidemiologic study performed at The Ohio State Veterinary Teaching Hospital found that the average duration of treatment for horses that improved clinically was 128 ± 123 days, compared to 76 ± 86 days for those that did not improve.¹⁵

There is only one other report studying the proportion of horses that die or are euthanatized because of EPM that has been published previously.³³ In this study, about 10 percent of last cases of EPM that de-

veloped between 1992 and 1996 died or were euthanatized because of EPM in the general horse population compared to 45 percent case fatality reported in that previous study performed at a referral center.³³ Among cases that developed during the previous year almost 5 percent were reported to have died or were euthanatized, but this difference was probably affected by differences in elapsed time between the onset of disease and the interviews for this study. About 15 percent of affected horses reportedly were sold or given away because of EPM. However, it cannot be determined from this study whether horses' conditions improved or stabilized prior to sale or if buyers had been made aware of horses' disease history.

While EPM does not apparently occur with great frequency in the U.S. horse population (approximately 14 new cases per 10,000 horses per year), the consequences of disease are substantial and costly. Only 49.6 percent (SE=16.7%) of owner-reported EPM cases that developed between 1992-1996 were reported to have recovered completely. For horses described as the last case of EPM (most recent) and whose disease was greater than 3 months in duration at the time of the Equine '98 interview, the median cost of diagnostic testing, veterinary care, and medications, through the day of the Equine '98 interview was \$1,000 per case (range 0 to \$10,000). Approximately 10 percent of the last EPM case reported to have no lost use. Among EPM cases at least 1 day of lost use and which were reported to have survived and not lost to follow-up, the median number of days of lost use attributed to EPM was 150 days (range 2 to 725 days; Table I.D.6b). Among last cases that died or were euthanatized because of EPM, an average of 9.2 years (SE=1.5 years) of lost use was attributed to illness related to EPM (assuming average life span of 20 years). Using information collected during the Equine '98 study, economists from the USDA have estimated that the average cost to the equine industry in the U.S. because of EPM is \$27 million annually.⁵² This total includes estimates for costs related to diagnosis, treatment, maintenance of horse while they are unable to be used for their intended purpose, lost use attributable to death, and the value of horses that die or are euthanatized. This estimate does not account for opportunity losses because affected horses are unable to attain their ultimate performance potential. These costs are substantial but are much lower than national estimates of annual economic impact associated with colic in horses and far less than the losses to the equine industry that can be attributed to lameness.⁵²

References

1. Dubey JP, Davis SW, Speer CA, et al. *Sarcocystis neurona* N. sp. (Protozoa: Apicomplexa), the etiologic agent of equine protozoal myeloencephalitis. *J Parasitol* 1991;77:212-218.
2. Granstrom DE, Dubey JP, Davis SW, et al. Equine protozoal myeloencephalitis: antigen analysis of cultured *Sarcocystis neurona* merozoites. *J Vet Diagn Invest* 1993;5:88-90.
3. Granstrom DE, Dubey JP, Giles RC, et al. Equine protozoal myeloencephalitis: Biology and epidemiology. In: *Equine Infectious Diseases VII. Proceedings of the Seventh International Conference*. 1994. pp 109-111.
4. Granstrom DE, Saville WJ. Equine Protozoal Myeloencephalitis In: SM Reed and WM Bayly, eds. *Equine Internal Medicine*. Philadelphia, Pa.: WB Saunders Company, 1998;486-491.
5. MacKay RJ, Granstrom DE, Saville WJ, et al. Equine protozoal myeloencephalitis. *Vet Clin North Am Equine Pract.* 2000;16:405-425.
6. Dubey JP, Lindsay DS, Saville WJ, et al. A review of *Sarcocystis neurona* and equine protozoal myeloencephalitis (EPM). *Vet Parasitol.* 2001; 95:89-131.
7. Lindsay DS, Steinberg H, Dubielzig RR, et al. Central nervous system neosporosis in a foal. *J Vet Diagn Invest* 1996; 8:507-510.
8. Daft BM, Barr BC, Collins N, Syerlow K. *Neospora* encephalomyelitis polyradiculoneuritis in an aged mare with Cushing's disease. *Equine Vet J* 1996; 28:240-243.
9. Marsh AE, Barr BC, Madigan J, et al. Neosporosis as a cause of equine protozoal myeloencephalitis. *J Am Vet Med Assoc* 1996; 209:1907-1913.
10. Hamir AN, Tornquist SJ, Gerros TC, et al. *Neospora caninum*- associated equine protozoal myeloencephalitis. *Vet Parasitol* 1998; 79: 269-274.
11. Fenger CK, Granstrom DE, Langemeier JL, et al. Identification of opossums (*Didelphis virginiana*) as the putative definitive host of *Sarcocystis neurona*. *J Parasitol.* 1995;81: 916-919.
12. Dubey JP, Saville WJA, Lindsay DS, et al. Completion of the life cycle of *Sarcocystis neurona*. *J Parasitol.* 2000; 86:1276-1280.
13. National Animal Health Monitoring System, 1997. NAHMS Equine '98: Needs assessment survey results. United States Department of Agriculture: Animal Plant Health Inspection Service: Veterinary Services, Fort Collins, CO, #N207.597
14. Bernard WV. Equine protozoal myelitis – laboratory tests and interpretation. In: *Proceedings of the International Equine Neurology Conference*. 1997. pp 7-11.
15. Saville WJA. The Epidemiology of Equine Protozoal Myeloencephalitis (EPM). Ph.D. dissertation. The Ohio State University, Columbus, OH, 1998, pp 223.
16. Saville WJ, Stich RW, Reed SM, et al. Utilization of stress in the development of an equine model for equine protozoal myeloencephalitis. *Vet Parasitol.* 2001; 95:211-222.

17. Immunoconversion against *Sarcocystis neurona* in normal and dexamethasone-treated horses challenged with *S. neurona* sporocysts. *Vet Parasitol.* 2001; 95:197-210.
18. Hamir AN, Moser G, Galligan DT, et al. Immunohistochemical study to demonstrate *Sarcocystis neurona* in equine protozoal myeloencephalitis. *J Vet Diagn Invest.* 1993;5:418-422.
19. Davis SW, Speer CA, Dubey JP. *In vitro* cultivation of *Sarcocystis neurona* from the spinal cord of a horse with equine protozoal myelitis. *J Parasitol.* 1991;77:789-792.
20. Granstrom DE. Diagnosis of equine protozoal myeloencephalitis: Western blot analysis. In: *Proceedings of the American College of Veterinary Internal Medicine Forum* 1993; pp 587-590.
21. Rossano MG, Mansfield LS, Kaneene JB, et al. Improvement of western blot test specificity for detecting equine serum antibodies to *Sarcocystis neurona*. *J Vet Diagn Invest.* 2000;12:28-32.
22. Lindsay DS, Dubey JP. Direct agglutination test for the detection of antibodies to *Sarcocystis neurona* in experimentally infected animals. *Vet Parasitol.* 2001;95:179-186.
23. Dame JB, MacKay RJ, Yowell CA, et al. *Sarcocystis falcatula* from passerine and psittacine birds: synonymy with *Sarcocystis neurona*, agent of equine protozoal myeloencephalitis. *J Parasitol.* 1995;81:930-935.
24. Marsh AE, Barr BC, Madigan J, et al. Sequence analysis and polymerase chain reaction amplification of small subunit ribosomal DNA from *Sarcocystis neurona*. *Am J Vet Res.* 1996; 57:975-981.
25. Bentz BG, Granstrom D, Stamper S. Seroprevalence of antibodies to *Sarcocystis neurona* in horses residing in a county of southeastern Pennsylvania. *J Am Vet Med Assoc* 1997;210:517-518.
26. Blythe LL, Granstrom DE, Hansen DE, et al. Seroprevalence of antibodies to *Sarcocystis neurona* in horses residing in Oregon. *J Am Vet Med Assoc* 1997;210:525-527.
27. Saville WJ, Reed SM, Granstrom DE, et al. Prevalence of serum antibodies to *Sarcocystis neurona* in horses residing in Ohio. *J Am Vet Med Assoc* 1997;210:519-524.
28. Granstrom DE. Equine protozoal myeloencephalitis testing: review of 1993 and 1994. In: *Proceedings of the 41st Annual Convention of the American Association of Equine Practitioners*, Lexington, KY, 1995, pp 218-219.
29. Tillotson K, McCue PM, Granstrom DE, et al. Seroprevalence of antibodies to *Sarcocystis neurona* in horses residing in Northern Colorado. *J Equine Vet Sci.* 1999;19:122-126.
30. Rossano MG, Kaneene JB, Marteniuk JV, et al. The seroprevalence of antibodies to *Sarcocystis neurona* in Michigan equids. *Prev Vet Med* 2001; 48:113-128.
31. Vardeleon D, Marsh AE, Thorne JG. Prevalence of *Neospora hughesi* and *Sarcocystis neurona* antibodies in horses from various geographical locations. *Vet Parasitol.* 2001; 95:273-282.
32. Saville WJA, Morley PS, Reed SM, et al. Analysis of risk factors for the development of equine protozoal myeloencephalitis in horses. *J Am Vet Med Assoc* 2000;217:1174-1180.

33. Saville WJA, Reed SM, Morley PS, et al. Evaluation of risk factors associated with clinical improvement and survival of horses with equine protozoal myeloencephalitis. *J Am Vet Med Assoc* 2000;217:1181-1185.
34. Hackstein JH, Mackenstedt U, Mehlhorn H, et al. Parasitic apicomplexans harbor a chlorophyll a-D1 complex, the potential target for therapeutic triazines. *Parasitol Res.* 1995;81:207-216.
35. Dirikolu L, Lehner F, Natrass C, et al. Diclazuril in the horse: its identification and detection and preliminary pharmacokinetics. *J Vet Pharmacol Ther.* 1999;22:374-379.
36. Lindsay DS, Dubey JP. Determination of the activity of diclazuril against *Sarcocystis neurona* and *Sarcocystis falcatula* in cell cultures. *J Parasitol.* 2000;86:164-166.
37. Granstrom DE, McCrillis S, Wulff-Strobel C, et al. Diclazuril and equine protozoal myeloencephalitis. In: *Proceedings of the 43rd Annual Convention of the American Association of Equine Practitioners*, Phoenix, AZ, 1997, pp 13-14.
38. Cohen ND. What's up with diclazuril? *Comp Cont Educ Pract Vet* 1998; 20:1264-1265.
39. Dirikolu L, Lehner F, Natrass C, et al. Diclazuril in the horse: its identification and detection and preliminary pharmacokinetics. *J Vet Pharmacol Therapeut* 1999; 22:374-379.
40. Dubey JP, Fritz D, Lindsay DS, et al. Diclazuril preventive therapy of gamma interferon knockout mice fed *Sarcocystis neurona* sporocysts. *Vet Parasitol* 2001; 94: 257-263.
41. Furr M, Kennedy T. Cerebrospinal fluid and blood concentrations of toltrazuril 5% suspension in the horse after oral dosing. *Vet Therapeut* 2000; 1: 125-132.
42. Lindsay DS, Dubey JP, Kennedy TJ. Determination of the activity of ponazuril against *Sarcocystis neurona* in cell cultures. *Vet Parasitol* 2000; 92:165-169.
43. Lindsay DS, Zhan Y, Dubey JP, et al. Determination of the activity of nitazoxanide against *Sarcocystis neurona* in cell cultures. In: *Proceedings of the American Association of Veterinary Parasitology Annual Meeting*, Baltimore MD, 2000, p 44.
44. Fenger CK, Granstrom DE, Langemeier JL, Stamper S. Equine protozoal myeloencephalitis: acupuncture diagnosis. In: *Proceedings of the 43rd Annual Convention of the American Association of Equine Practitioners*, 1997, Phoenix AZ, pp 327-329.
45. Cutler TJ, MacKay RJ, Ginn PE, et al. Are *Sarcocystis neurona* and *Sarcocystis falcatula* synonymous? A horse infection challenge. *J Parasitol* 1999; 85: 301-305.
46. Beech J, Dodd DC. Toxoplasma-like encephalomyelitis in the horse. *Vet Pathol* 1974;11:87-96.
47. Beech J. Equine protozoan encephalomyelitis. *Vet Med Small Anim Clin* 1974; 69:1562-1566.
48. Fenger CK, Granstrom DE, Langemeier JL, et al. Equine protozoal myeloencephalitis: findings from a retrospective study. In: *Proceedings of the 42nd Annual Convention of the American Association of Equine Practitioners*, 1996, pp 80-81.
49. Reed SM, Saville WJA. Equine protozoal encephalomyelitis. In: *Proceedings of the 42nd Annual Convention of the American Association of Equine Practitioners*, 1996, pp 75-79.

50. Moore B, Granstrom D, Reed S. Diagnosis of equine protozoal myeloencephalitis and cervical stenotic myelopathy. *Comp Cont Educ Pract Vet* 1995; 17:419-426.
51. Fenger CK. Update on the diagnosis and treatment of Equine Protozoal Myeloencephalitis (EPM). In: *Proceedings of the 13th American College of Veterinary Internal Medicine Forum*, 1995; pp 597-599.
52. Seitzinger AH, Traub-Dargatz JL, Kane AJ, et al. A comparison of the economic costs of equine lameness, colic, and equine protozoal myeloencephalitis (EPM). In: *Proceedings of the 9th Symposium of the International Society for Veterinary Epidemiology and Economics*. Eds: Salman MD, Morley PS, Ruch-Gallie R. Breckenridge, CO, 2000. pp 1048.

Appendix I: Sample Profile

A. Responding Operations (April 20 through June 12, 1998)

1. Type of operation

Primary Function of Operation	Responding Operations
Boarding/Training facility	381
Breeding farm	199
Farm/Ranch	219
Residence with equids for personal use	228
Other	<u>151</u>
Total	1,178

2. Region

Region	Responding Operations
Southern	435
Northeast	155
Western	323
Central	<u>265</u>
Total	1,178

3. Horses on hand January 1, 1998

Number	Responding Operations
3 - 5*	273
6 - 19	449
20 or more	<u>456</u>
Total	1,178

*Three premises with two horses on hand on January 1, 1998, completed this portion of the study.

Appendix II: U.S. Equine Populations

Region	State	Census: Number Horses and Ponies ¹ on Farms (Thousand Head)		Census: Number Farms Reporting Horses and Ponies ¹ (Thousand Farms)		NASS: Number Equine ² - All Lo- cations (Thousand Head)
		1992	1997	1992	1997	January 1, 1998
Central	Illinois	46.1	51.7	7.3	7.6	99.0
	Indiana	48.1	58.6	8.4	9.2	140.0
	Kansas	42.9	52.8	9.7	10.6	104.0
	Michigan	54.0	66.2	7.8	9.1	130.0
	Minnesota	43.1	55.9	7.7	8.8	155.0
	Missouri	64.6	85.7	14.2	15.9	140.0
	Wisconsin	<u>43.6</u>	<u>52.4</u>	<u>8.1</u>	<u>8.8</u>	<u>115.0</u>
	Total	342.4	423.3	63.2	70.0	883.0
Northeast	New Jersey	23.9	22.6	2.5	2.3	45.0
	New York	43.3	47.8	6.4	6.5	157.0
	Ohio	72.0	76.2	10.9	11.7	155.0
	Pennsylvania	<u>58.0</u>	<u>65.1</u>	<u>9.2</u>	<u>9.9</u>	<u>165.0</u>
	Total	197.2	211.7	29.0	30.4	522.0
Southern	Alabama	29.7	42.5	5.7	7.4	130.0
	Florida	52.0	54.9	6.7	6.8	170.0
	Georgia	31.1	35.3	5.6	5.9	69.0
	Kentucky	78.1	95.9	12.4	13.4	150.0
	Louisiana	28.0	30.1	5.1	5.3	65.0
	Maryland	24.3	22.5	2.8	2.6	45.0
	Oklahoma	70.0	93.7	14.9	18.4	165.0
	Tennessee	61.1	89.0	12.4	15.3	185.0
	Texas	209.1	242.0	38.5	44.2	595.0
	Virginia	<u>44.0</u>	<u>50.3</u>	<u>7.1</u>	<u>7.5</u>	<u>145.0</u>
	Total	627.4	756.2	111.2	126.8	1,719.0
Western	California	124.9	113.1	15.0	13.0	235.0
	Colorado	69.4	81.7	9.9	11.2	140.0
	Montana	56.4	71.2	8.2	10.2	130.0
	New Mexico	41.4	38.8	5.7	5.9	64.0
	Oregon	51.9	68.3	9.2	10.7	120.0
	Washington	51.1	58.8	7.9	8.1	155.0
	Wyoming	<u>40.7</u>	<u>50.6</u>	<u>4.5</u>	<u>5.3</u>	<u>61.0</u>
	Total	435.8	482.5	60.4	64.4	905.0
Total (28 states)		1,602.8 (78.2% of US)	1,873.7 (77.2% of US)	263.8 (78.0% of US)	291.6 (77.7% of US)	4,029.0 (76.7% of US)
Total U.S. (50 states)		2,049.5	2,427.3	338.3	375.2	5,250.4

1 Horses and ponies and farms reporting horses and ponies. Source: Census of Agriculture 1992 and 1997.

2 Equine includes horses, ponies, mules, burros, and donkeys. Equine located on farms totaled 3.20 million head and 2.05 million head were located on non-farm places. Source: National Agricultural Statistics Service (NASS), March 2, 1999.



Completed and Expected Equine '98 Study Outputs and Related Study Objectives

1. Provide baseline information on equine health.
 - Part I: Baseline Reference of 1998 Equine Health and Management, August 1998
 - Part II: Baseline Reference of 1998 Equine Health and Management, September 1998
 - Equine morbidity and mortality (info sheet), September 1998
2. Estimate uses of equine health-related management practices.
 - Part II: Baseline Reference of 1998 Equine Health and Management, September 1998
 - Part III: Management and Health of Horses in the U.S., 1998, January 1999
 - Part IV: Reference of Health Management for Horses and Highlighted Diseases, 1998, May 1999
 - Sources of information/use of veterinarian (info sheet), August 1998
 - Biosecurity practices on U.S. equine facilities (info sheet), August 1998
 - Information sources and use of veterinarians for equine health care, August 1998
 - Unique identification methods for U.S. equids (info sheet), May 1999
 - Equine management practices (info sheet), January 1999
 - Transportation of U.S. equids (info sheet), January 1999
3. Determine type and use of animals in the U.S. equine population by type of operation.
 - Part I: Baseline Reference of 1998 Equine Health and Management, August 1998
 - Composition of the U.S. equine population (info sheet), August 1998
4. Measure the prevalence of specific infectious agents or frequency of antibodies to specific infectious agents.
 - *Salmonella* and the U.S. horse population (info sheet), May 2001
 - Internal parasites: strongyles and ascarids (info sheets), April 2000
5. Gather data related to specific health problems.
 - Testing for equine infectious anemia (EIA) in the U.S. (info sheet), September 1998
 - Equine Viral Arteritis (EVA) and the U.S. Horse Industry (interpretive report), April 2000
 - Lameness and Laminitis in U.S. Horses (interpretive report), April 2000
 - ***Equine Protozoal Myeloencephalitis (EPM) in the U.S.***, (interpretive report), May 2001
 - Mortality (info sheet), 1997-1998, May 2001
 - Colic (info sheet), expected summer 2001
 - Respiratory disease (info sheet), expected summer 2001
 - National Economic Cost of Lameness, Colic and EPM (info sheet), expected summer 2001
6. Feed problems.
 - Endophytes in U.S. horse pastures (info sheet), April 2000
 - Fumonisin B₁ mycotoxins in horse grain/concentrate on U.S. horse operations (info sheet), April 2000

Centers for Epidemiology and Animal Health

USDA:APHIS:VS, attn. NAHMS
555 South Howes; Fort Collins, CO 80521
Telephone: (970) 490-8000
NAHMSweb@aphis.usda.gov
<http://www.aphis.usda.gov/vs/ceah/cahm>

#N312.0501